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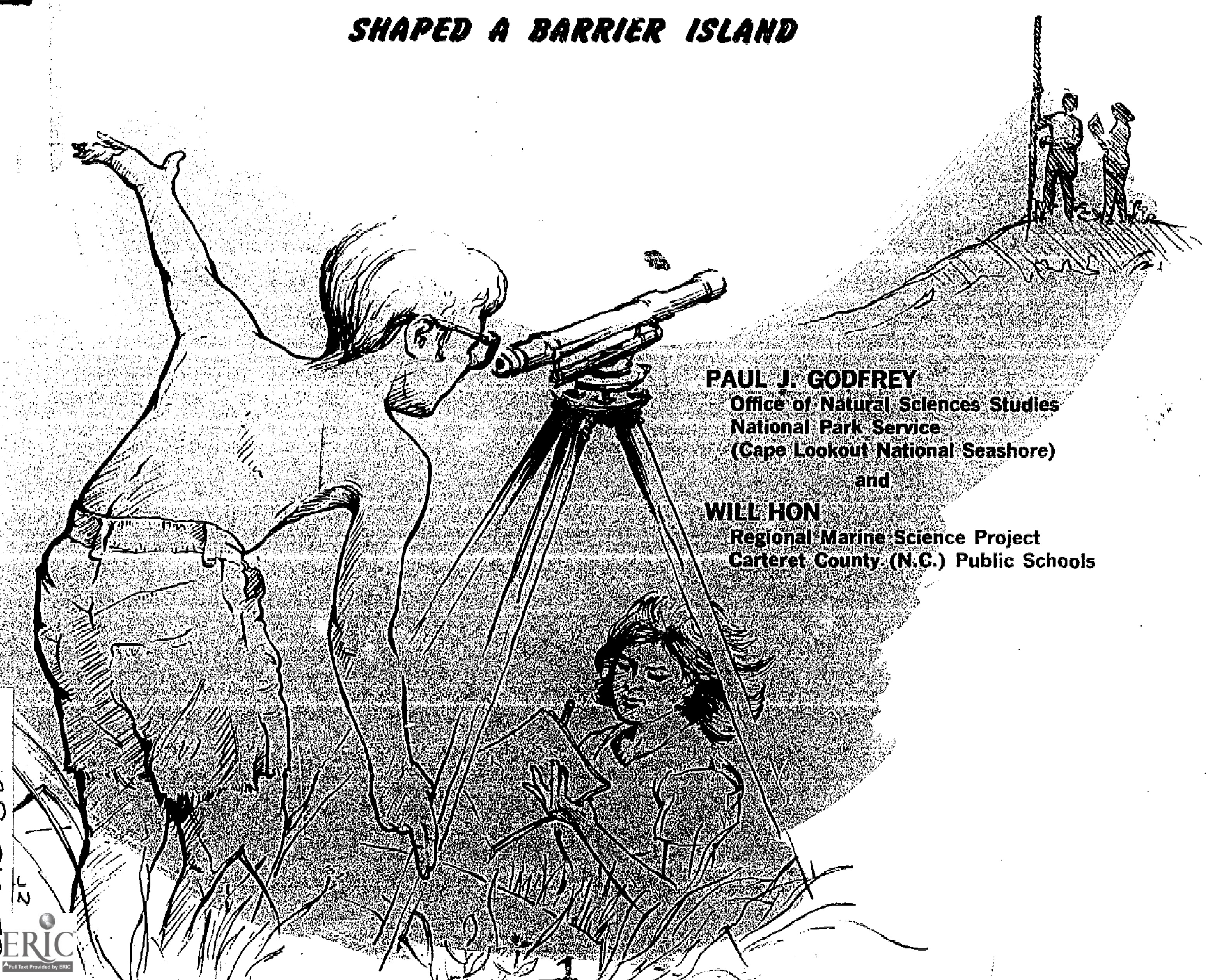
ABSTRACT

This publication is designed for use as part of a curriculum series developed by the Regional Marine Science Project. Students in grades 11 and 12 are exposed to research methods through a series of field exercises guiding investigators in reconstructing the events which have shaped the natural communities of a barrier beach. Background information, field equipment, field assignments, procedures, results and discussion ideas are provided for six exercises: dune survey, washover--physical aspects, washover--ecological succession, maritime forest profile, salt marsh survey--mapping, and salt marsh survey--elevations. Numerous line drawings, diagrams, charts, and photos supplement the narrative material. This work was prepared under an ESEA Title III contract. (PR)

DUNE DETECTIVE

USING ECOLOGICAL STUDIES TO RECONSTRUCT EVENTS WHICH SHAPED A BARRIER ISLAND



PAUL J. GODFREY
Office of Natural Sciences Studies
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and

WILL HON
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FUN WITH A PURPOSE

Sleuthing is a major element in scientific investigation. Research is, by its very concept, an adventure into a frontier, testing a hypothetical thread of logic which may or may not link known to unknown.

Students who are tackling scientific methodology for the first time have trouble translating broad areas of study down into practical "bite-size" fragments for research problems. Graduate schools are plagued with this same bottleneck, at which very advanced students squirm awkwardly in search of "the right problem". High school students and undergraduates can therefore be forgiven their confusion about what makes a good research problem.

The purpose of these field exercises is to demonstrate the whole process of research by throwing students into real situations in which they are encouraged to think imaginatively, yet learn the use of standard field ecology techniques in loosely predetermined problems.

DESIGNING A RESEARCH TRIP

Each exercise described here will require several hours of serious effort by a small group of capable students. You will then need an hour or so for the student investigators to pull together a summary of results and another hour for oral reports. Therefore, it is possible to meet students and go to the study site early in the morning, have a sack lunch, and complete the "seminar" afterward. The students will find this far superior to most of the research they have done in the past. However, an even better way is to make an overnight trip of it.

If you have the means, take them to an island or other isolated spot after school on a Friday afternoon. Take both boys and girls (and enough chaperones) and the whole project becomes high adventure. Let the girls plan and cook supper and breakfast, and let the boys handle the logistical problems, such as living quarters and garbage disposal. Rustic fish camps or summer cottages make ideal facilities . . . not too crude, but not too plush. If you decide that the students will have a real problem planning and preparing meals, take simple pre-fixed stuff and mess with cooking as little as possible. Lunch should certainly be sandwiches; quick, portable and easily personalized to individual taste. Plenty of water is essential. Iced soft drinks and insect repellent will make a tremendous difference in the mood of the trip.

WHO TO TAKE

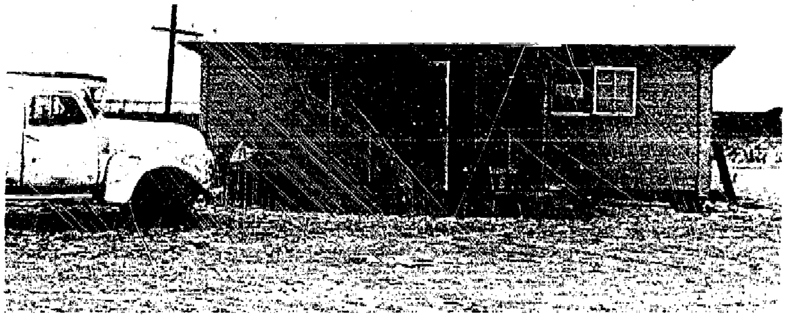
These exercises are pretty demanding. Their chief advantage is that they throw a student group on its own, to use standard research techniques in a creative way. If modified and carefully explained, these exercises could be useful for less adept students, who would find them fascinating. However, as here presented, the research problems will be of most benefit to serious, talented students with inclinations toward scientific careers. It is a fine opportunity for the biology teachers to work closely with students who will take advantage of the extra effort this trip will require of the staff. A good approach when asking for volunteers for such a venture is to stress the hard work and to discourage any who would go just to play. For example, a girl will often ask if her boy friend, who is not in the class, can go along, and this is precisely what you are trying **not** to do. Say "NO", and take students who expect to give you free slave labor.

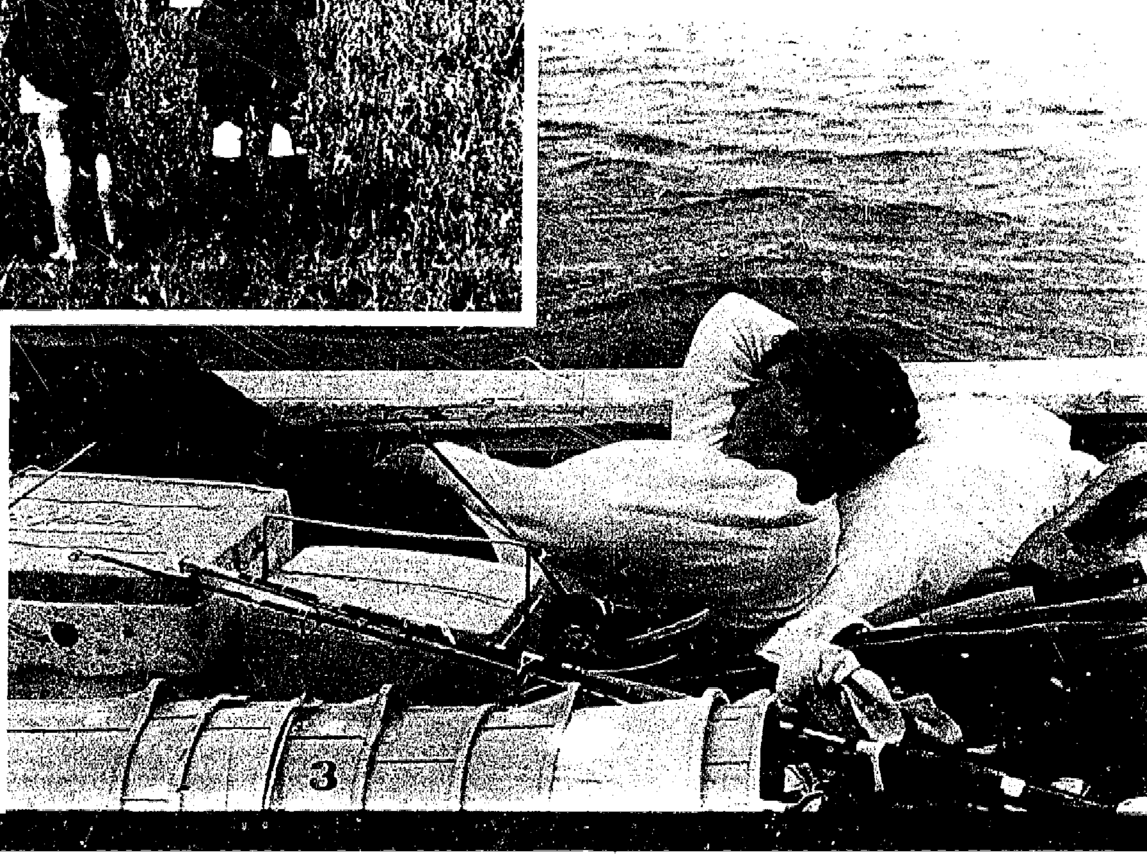
The ideal number, in terms of social dynamics and the available exercises, is about twenty students. This assumes that you can put in the field several good biology teachers who can constantly steer the work and answer questions . . . and ASK good questions, too.

EDUCATIONAL VALUES OF THE TRIP

In whatever form these exercises are used, their content is the methodology of science applied to a specific and intriguing coastal environment. The little research problems which are the core of these exercises have these advantages:

1. Each one spans the research process: defines a broad problem, selects a specific area for investigation, poses a few answerable questions and outlines methods for collecting appropriate data.
2. Each problem requires simple equipment and easily-mastered techniques, yet leaves room for individual ingenuity.
3. The data collected is easily analyzed but, far from "proving" anything, indicates the need for much more data and for supportive studies of related problems.
4. The close correlation between these problems solves some of the aforementioned need, and a good swapping of ideas after a morning of single-group studies will yield a pretty comprehensive picture of the forces at work on a barrier island.





TIME REQUIREMENTS

Experience indicates that the following schedule should be realistic and fruitful:

4 p.m. Meet at the school or dock, having made all arrangements, including: parental and administrative permission; insurance coverage; food, lodging and transportation; return schedule and emergency procedures.

6 p.m. Be set up in camp, ready to fix or serve supper.

8 p.m. Orientation to the area of study and major physical processes. If electricity is available, it could include the films "The Beach: A River of Sand" and/or "Dune Succession". Review the forces of wind, waves, tides, sun, salt spray, storm, littoral drift and animal disturbance which are operating on and around the area. Do not take the fun out of the problems by discussing them specifically. Keep the talk to an hour so students will have time to chat, explore and build a bonfire.

7 a.m. Prepare a hot but simple breakfast.

8 a.m. Divide the mob into suitable groups, mixing sexes, brainpower, and students from different schools, if available, Assign or let them select a group leader to receive printed materials. Give the group half an hour to evaluate its mandate.

9 a.m. Start out on a walking tour of the study area, identifying physical features and chief plant species. This will lead to the areas where individual groups will work while transect suggestions are being made by the trip leader or other instructors. After this, adults should be available but not hovering over the students.

12 noon Lunch and a relaxed period in which each group can collect its thoughts and data, and prepare to discuss its findings.

1:30 p.m. Convene the groups and let one or (preferably) more members of each get up and explain their findings and their hypotheses about the larger questions posed by their exercise. Have available a crayon and a large drawing surface, such as brown wrapping paper or a big cardboard box, flattened, or even an old door, so that the profiles can be sketched and data crudely plotted.

There is no time limit, but ten or fifteen minutes per group is usually enough for each group to state its case and field the questions tossed to it by students or (as a last resort) a trip leader. In about an hour the major ideas will have been covered, the later discussions overlapping the first. The trip leader can see that no major gaps are left and that everyone has an overall view of some of the processes that shape the barrier island.

3:00 p.m. Clean up and head home.

THE AFTERMATH

The extent of the trip's success will be proportional to how hard the students have worked. This goes deeper than just outcome-is-proportional-to-input. It relates to the fact that students really want to work at something **worthwhile**, but resist most efforts to make them work because it all seems irrelevant. If they work themselves to a frazzle all weekend they will talk for weeks of the "fun" they had and imply with pride that they overcame great hardships. They will subconsciously respect you and research for having "turned them on". If, on the other hand, you try to appease them with a lot of time to loaf and easy assignments, it will be just another wasted weekend for them and the reminiscing will be about the escapades of the weekend clown.

Therefore, plan carefully so that you have every hour under control and can convey a sense of genuine urgency about getting on with some valuable work. However, you can't make the students work hard; you can only inspire them to do so.

FIELD EXERCISE No. 1

Dune Survey

Objective:

Determine the way beach grasses form sand dunes and observe the development of vegetation as a function of dune growth.

Background:

The growth of dunes along sandy seashores is a continuous and important geophysical part of the maritime environment. The dunes conserve fine sand moved off the beach by winds, they show a rapid, but narrow, elevational increase of the land, and they provide a first line of resistance to oceanic washover. The growth of dunes and the process of washover (being studied by other students) work together as part of the island building system. Washover deposits sand over a wide area as a result of a major storm, and it generally occurs infrequently. The source of this sand is both the beach and dunes. Once washover build-up occurs, dunes develop on the new surface and grow continuously as long as there is a source of sand and vegetation to trap the sand. Long intervals between major storms will result in substantial dune growth and the development of distinctive vegetation. The building of dunes is a continuous process and occurs whenever wind speeds are high enough to move sand off the bare beach. The sand stops moving, however, where it first meets resistance from beach vegetation. Here the dunes may grow a foot or more in a year. Whereever vegetation is lacking, the sand is free to move. As dunes build, they provide protection for life in the interior of the island by reducing the amount of salt spray that comes across from the sea and by slowing down and reducing the frequency of washover. Such growth leads to relative stability so that other forms of life not adapted to salt spray and moving sand, as is the dune vegetation, can survive. In some areas, forest vegetation results from this stability and the forest will migrate in the direction of the most stable dune lines. Thus, plant succession follows the build-up of dunes. Many ecological lessons can be learned on the dunes, and it is impossible to cover them all in one exercise. Some famous ecologists have built their whole careers around the study of sand dune development and succession. However, we can start by making a few general observations on the growth of dunes and subsequent plant succession.

Keep in mind that we are observing an environment of constant change and flexibility. Nothing is stable for very long and a series of severe storms during a period of rising sea levels can cause drastic changes—dunes knocked down, forests destroyed, grasslands buried. Yet, in a short time, the islands recover, new dunes grow, and forests redevelop. This is how the barrier islands survive. Flexibility and change is the key to their continual existence in the face of the mighty sea. If sea level falls dune lines will follow the beach out as more land is exposed and the islands thus widen seaward. As sea level rises, dune lines are knocked back, washover pushes sand over the land, and the islands migrate slowly toward the mainland. You are to determine how your observations on dune growth fit into the studies being made by the other groups at work on the beach.

Field Equipment:

Shovel, yardstick, 1-meter quadrat, tape measure, data forms, drawing paper, clipboards.

Field Assignment:

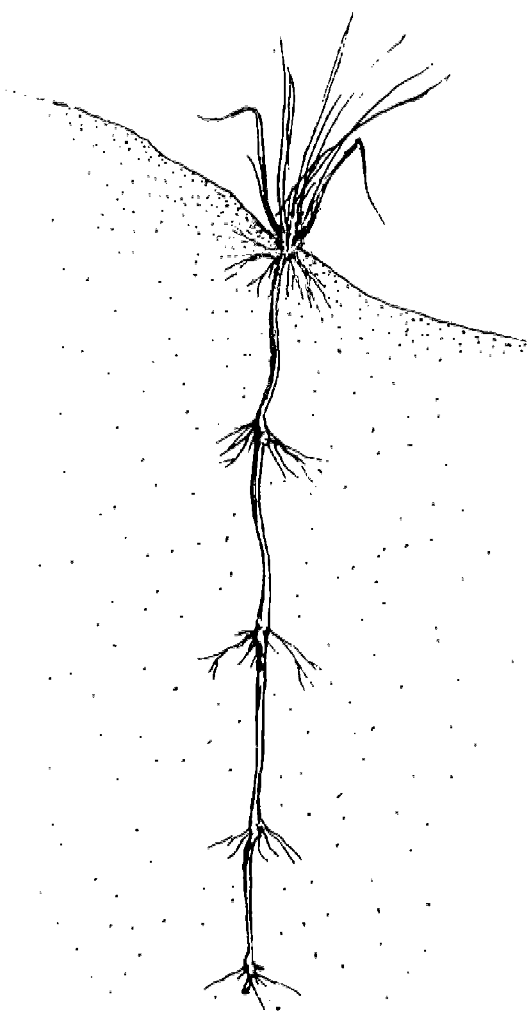
Your group will make a close examination of the structure of major dune grasses and a transect across the dune strand (as ecologists call dune vegetation) to determine how dunes form and then how the vegetation changes as the dune line grows. With the 1-meter quadrat (a wooden frame 1 meter square), the vegetation along this dune transect can be given a rough quantitative analysis in the manner of published ecological studies.

Divide your group into two subgroups, one to study each part of this exercise.

Procedure:

Dune growth — subgroup No. 1

Go out on the bare berm — the flat area that is usually above the beach slope—and look for newly formed dunes. These may be small piles of sand behind a tuft of grass. What is this grass? How did it start where it is? Find a somewhat larger dune and carefully dig the grass out. What do you notice about the structure of the grass? How much of this year's growth has been covered by new sand? How much occurred last year? By counting nodes (the swollen portions of the buried plant stem) and measuring the distance between the nodes, you can tell how old the grass plant is and how much sand was deposited each year.



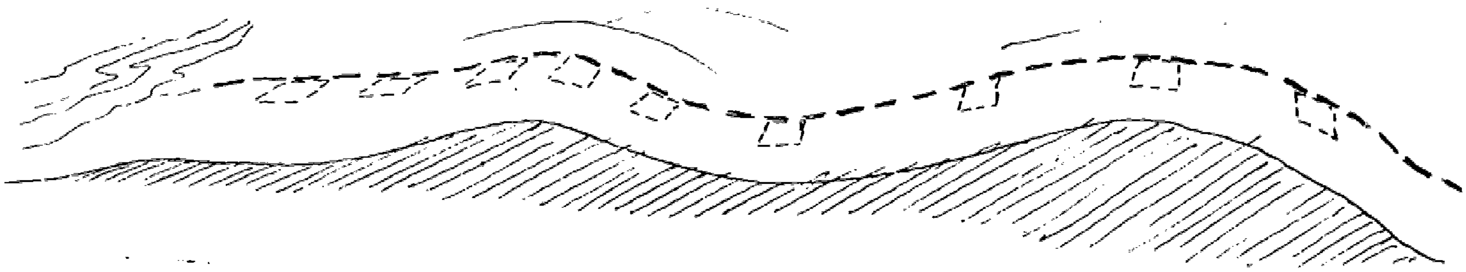
You should see that this grass has the ability to grow upward as it is buried. How does the grass grow laterally? Find a distinct row of plants that run out of the dune and carefully dig the row up. What do you find?

Diagram the structure of the plant and its lateral growth. The connecting rootlike structure between young plants is called a "rhizome" and ties the new plants to their parent until they can take over on their own. Measure the distance from the parent plant to the youngest and measure the distance between plants. How far does the plant spread in a year? What does this mean with regard to starting new dunes or increasing the size of the first dune?

Look around on the berm for a group of small grass plants. Dig a few of them up. Are they connected? If not, can you tell how they started there? Can you find seeds attached to the plants? Why are they all bunched together? Is there anything else in that site to suggest whether the sea put the seeds in place or if they blew in?

BE SURE TO REPLANT ALL EXCAVATED GRASSES. MAKE DRAWINGS OF THE GRASSES TO ILLUSTRATE TALKS YOU WILL GIVE TO YOUR FELLOW STUDENTS.

Go back into the main dune line and look for a blow out, or an eroded dune side. See if you can find a whole grass plant that is exposed and follow it down from the top of the dune. Diagram the structure of the plant and the dune. How far down does the plant go? Is it a complete plant? How old is the dune line?



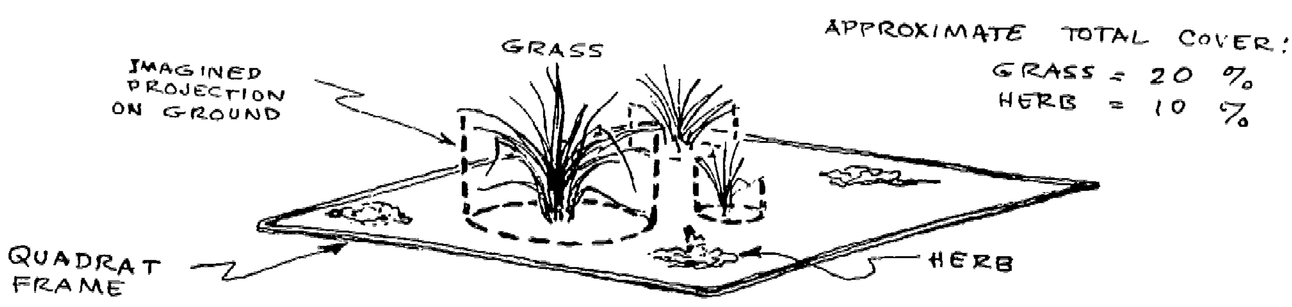
Dune Strand Transect — Subgroup No. 2

A transect is made by first laying out a line from the beach across the dunes, and then placing the quadrat down along this transect at measured intervals. The transect line can be merely a visual sighting, but it should be straight and certain features should be selected as sighting guides. Installing stakes along the line is a good practice and will assure proper alignment. Distances between quadrat locations can be measured or simply paced off.

Sampling. Start on the berm and place the quadrat down along the transect. Determine the major species present within the quadrat. If you don't know their names, temporarily make up your own that describe their features. However, be sure that you ask someone who knows or check a field guide as soon as possible. It is important to learn the identity of plants you are working with. Count the plants of each species and determine their DENSITY. This means the number of plants per quadrat. Since the quadrat is a square meter, you will have density = number of plants per square meter.

Then estimate how much area each species within the quadrat occupies as a percentage. This is called COVER. Cover is often estimated by imagining that the plant occupies a circle on the ground as a projection of its leaves. See the example above. This takes practice but you should get a reasonable guess after a while. It is often very helpful to first make a sketch of the plants within the quadrat, sort of a map, and then estimate the cover based on your sketch. Don't bother with the very small plants that might be present. Just identify them if you can. Concentrate on the dominants.

Then move the quadrat to the edge of the dunes and repeat the count. Next place it on the seaward face of the dunes, then on top, then on the back slope, next in the interdune area, then on the seaward face of the rear dune (if one is present), and finally on the back slope of the rear dune. Measure the distance between these quadrats and number each. There is, of course, no limit to the number of quadrats you could run along this transect. For very detailed studies the whole transect could consist of quadrats side by side. However, this involves a great deal of time and patience. For most purposes, several scattered plots along the transect will provide useful information. Run as many samples as you wish depending on the time available.

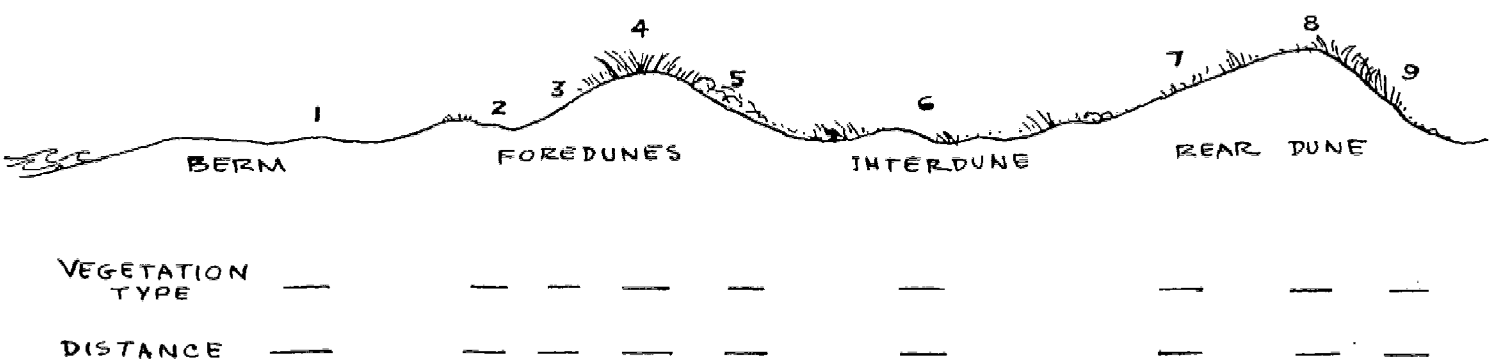


Arrange your data in a table as illustrated:

Species		Quadrats						
		1 Berm	2 Dune Edge	3 Dune Face	4 Dune Top	Dune Back	6	7
A	Density							
	Cover							
B	C							
	D							
C	C							
	D							
D	C							
	D							

Make a profile diagram, drawn to scale, showing the location of the quadrat along the transect and describe the major vegetation zones in relation to exposure and moving sand.

While making the transect, record anything you notice that will add to the story of the dune environment. Look for shrubs and other plants that may not be on your exact line, but are in the same general area. Is there a difference in vigor of the sea oats on the rear dune compared to those on the fore dunes? Are some greener than others? Why? Do you notice salt spray pruning of plants that reach above the protection of the first dunes?

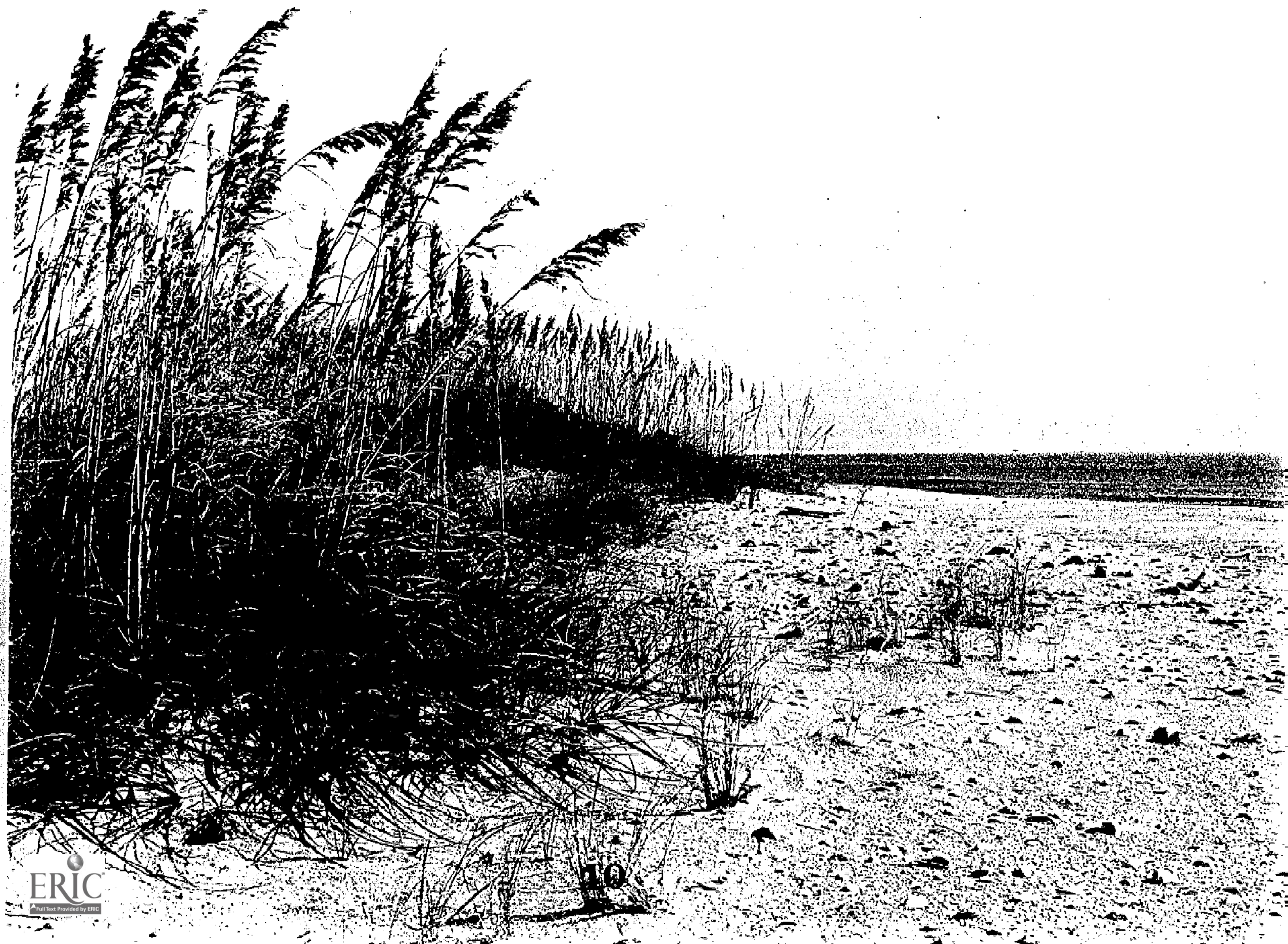


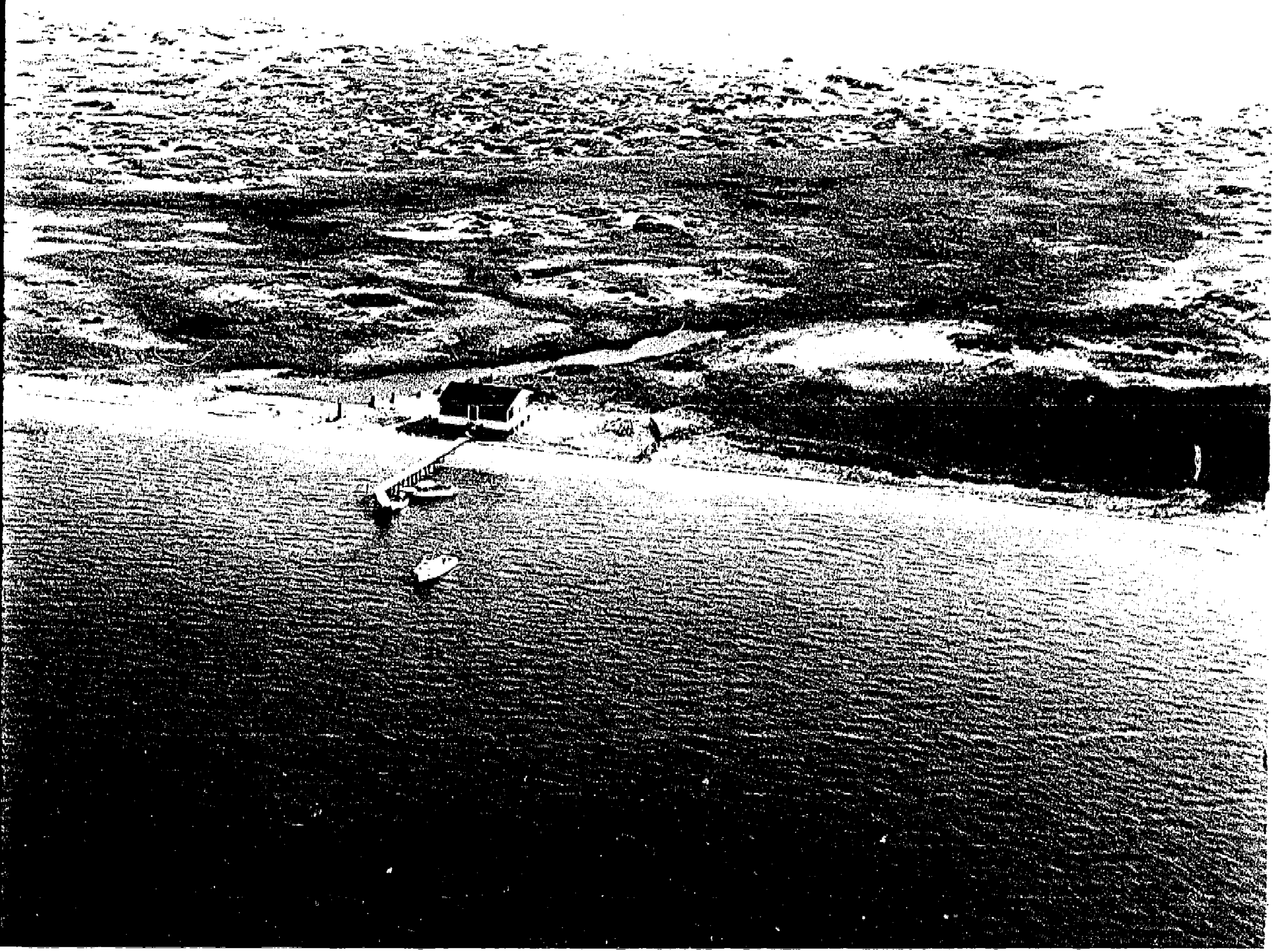
Results and Discussion:

Prepare your data as suggested and present your findings to the whole class. Consider the following points when making your analysis:

Group No. 1—Dune growth. What do your observations on the structure of beach grass (sea oats or American beach grass) tell you about its ability to survive burial by sand? How does the dune start to form? What does the grass do that causes the sand to collect around it? Why is a grass dune more effective as a sand trap than a fence? Can you tie in your knowledge of this building process with the information gathered by the group studying overwash? What will happen if the dunes build too high during a long quiet period without major storms? Do you think the ocean will reestablish a new equilibrium by knocking the dunes down? Can you make tentative conclusions about the effect that man-made barrier dunes have on the natural beach system? Why is erosion considered such a problem? What really is the cause of this trouble?

Group No. 2—Transect. With the data gathered along your transect you should have some idea of the plants distributed from the beach back across the dunes. What does this tell you about plants that can survive in the open? Which species are most resistant? Did you notice if the leaves of the plants on the dunes were wet? If they were, what made the wetness? Did you taste it? Why do different species occur in the lee of the dunes than on the face of the dunes? What is the most important environmental factor controlling the distribution of plants in the dunes? How will the vegetation change as the dunes grow and more stability develops? What will happen when the dunes are broken, either by natural or man-made effects? What is the most destructive thing that man does on the seashore and why?





FIELD EXERCISE No. 2

Washover—Physical Aspects

Objective:

Analyze the physical after-effects of washover on a low barrier island and relate this process to the future of the island and the sea-land interface.

Background:

There is considerable controversy on the importance of washover—the process by which storm driven water floods over a beach and inundates dune lines—to the future of barrier islands. Engineers and others fear that such a process is destructive and will lead to the eventual disintegration of the islands. Geologists and ecologists, on the other hand, feel that this is not the case, but that washover is part of a building process that ensures survival of the islands. Washover occurs regularly on low barrier islands where the land has not been modified by man. Storms drive sea water across the beach, through the dune lines, over the grasslands, and into the sounds. You will need to consider such questions as: What does washover actually do? Which argument do you think is the most accurate? What conditions could cause a loss of elevation or a build up? What factors are involved in the process? What would happen when washover is stopped? Is this result desirable or not?

Field Equipment:

Flat shovel, ruler or yardstick, notepaper, tape measure.

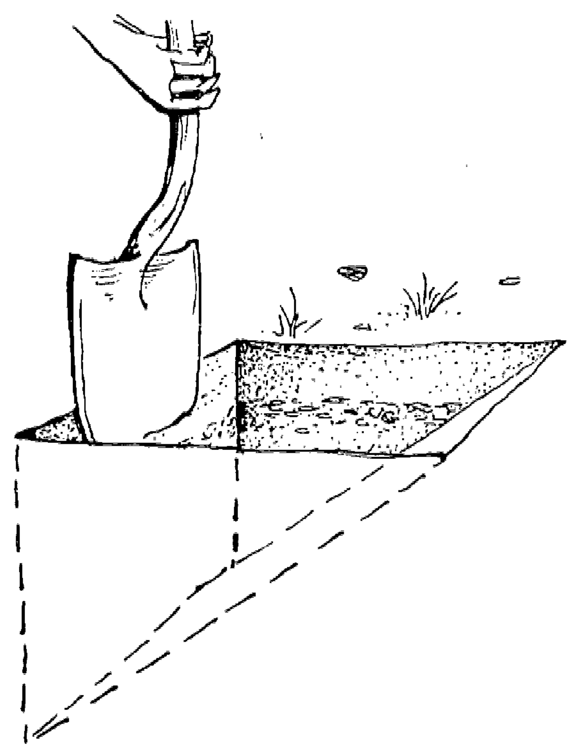
Field Assignment:

Your group will be working in conjunction with another group that is looking at plant succession, and you should be studying the same general area. The study site will be located for you by the trip leader, where the land is low and washover occurs with some regularity.

Designate members of your group to dig holes, measure, and record data.

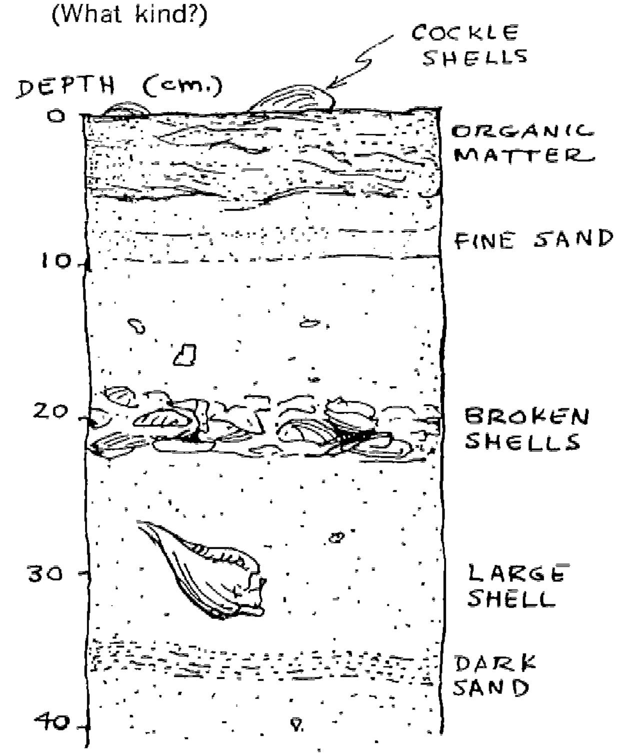
The object of the assignment is to make a series of soil profiles across the island and to describe the layers of sand observed. A soil profile is a diagram of a carefully excavated hole, of which one side is smoothed off and vertical.

For Example:



The diagram is made by simply sketching the layers of sand on note paper, to scale, and getting a rough idea of the width of the layers, as well as notes on their composition—e.g. fine sand, large or small shells, organic matter. A sample diagram is shown on the next page.

Shell on Surface
(What kind?)



Make notes on the kinds of shells found in the sand and compare with those found on the beach or along the sound. Where did they come from?

Profiles should be made on the open beach (#1), between dunes (#2), in the sparse grassland behind the dunes (#3), in the dense grassland toward the sound (#4), and near the sound edge (#5).
Pace off the distance from the beach berm scarp to the first profile and then to each succeeding profile. (The same person should always do the pacing.) If a tape measure is available, use that to determine between profiles.

The holes should be as deep as possible. Water may enter the holes near the middle of the island, but dig anyway—at least 1 1/2 feet deep—and note the appearance of the materials brought up.

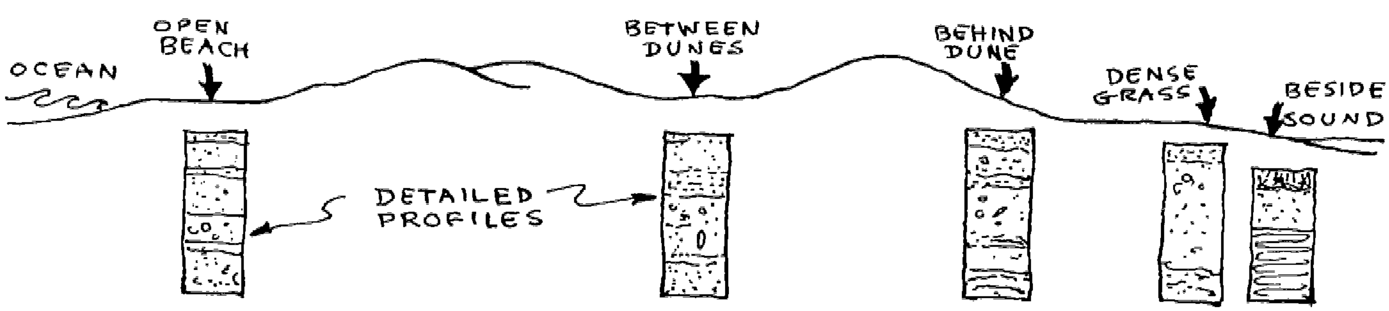
Try to find a dark black zone underneath the sand layers near the middle of the island—profiles #3 and #4. What is this layer? What does it signify? What happened to it?

BE SURE TO FILL IN ALL HOLES AFTER STUDY!

Results:

You should present your data as a diagram, drawn to scale, showing each profile and where it is located.
Then expand each profile diagram and compare.
You should then be able to tell the story of the washover, and what you think it is doing.

Get together with the other washover study group and discuss the sample diagrams of "Washover and succession on a barrier island". Explain the features of each stage. How do your data and observations compare with this model?



FIELD EXERCISE No. 3

Washover—Ecological Succession

Objective:

Determine plant succession on barrier islands subject to washover and relate it to the overall dynamics of the island system.

Background:

The process of washover—storm driven waters flooding across low barrier islands—is a dynamic environmental factor which controls succession of plant species on the island. Few environments have such a constantly changing force of the magnitude of washover, and few plants are adapted to this force. In addition, washover is considered destructive by some, but evidence is growing which demonstrates that the process is not destructive as long as vegetation is present. Vegetation, moving sand, and oceanic energy are closely tied together in a very dynamic and flexible system. You will try to unravel this system and to determine how plants are adapted to these forces. Questions such as: What are the main species present from the bare beach to the sound? Which are most important? How are they adapted to washover? What happens when washover occurs?

Field Equipment:

Grass shears, paper bags, weighing scale (or balance), small shovel, note paper and marking pen, 1/4 meter quadrat.

Field Assignment:

Your group will be working closely with the group studying the physical aspects of washover, and will be in the same general area.

The primary objective is to make a rough transect across the island, and to describe the plant communities and their major species from the bare beach to the sound side.

Collaborate with the other washover group and select sample sites on the bare beach, interdune area, sparse grassland, dense grassland. The 1/4 meter quadrat will be used to sample the vegetation.

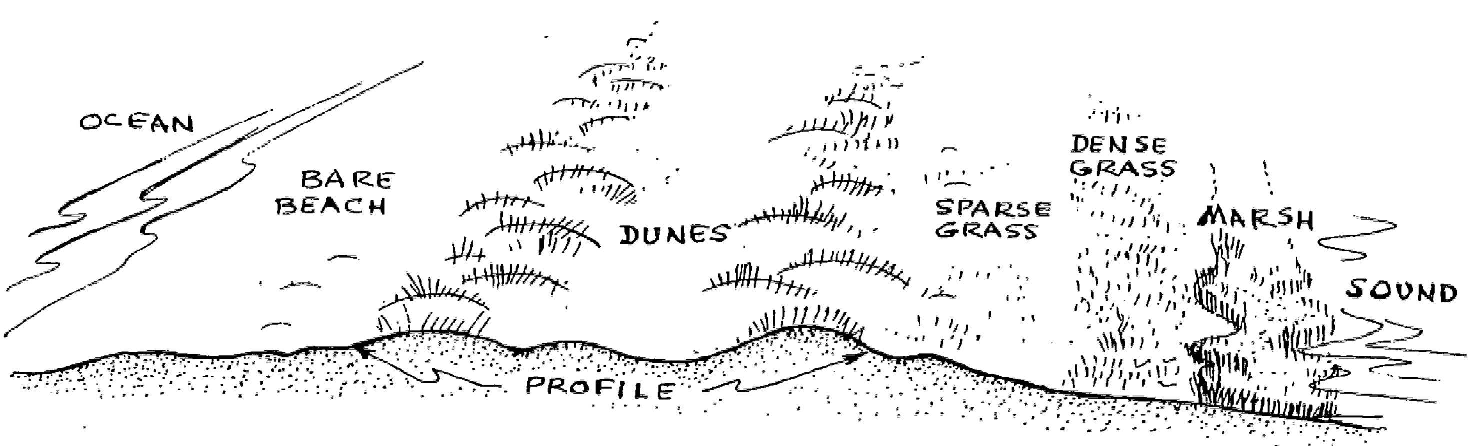
Sampling:

At each station, locate the quadrat on the ground at a randomly selected place—have someone stand facing away from the general site and throw a shell over his shoulder a short distance. Place a corner of the quadrat at the spot where the shell falls, and use the same corner everytime. Orient the quadrat in the same direction for each sample.

With the grass shears, carefully clip all the grass within the quadrat boundaries, place in a bag and label. Do this at least 2 times for each station.

Other Observations:

Carefully dig up several grasses in the sand flats and try to get their root systems out fairly intact. Store in a marked bag. What do the tree stumps tell you about past vegetation?



Working Up the Data:

1. Make a profile diagram of the transect showing the major communities.
2. Take the clipped samples, weigh each set to determine total standing crop, and then divide up each set into species groups and weigh each group. Make a table as follows:
3. Enter the average total weight of grass onto your profile diagram and then consider the results as they relate to the physical aspects of the area.

Station	Weight of Sample	Weight of Bag	Weight of Grass	Species A	Species B	Species C
1-a						
1-b						
Average						
2-a						
2-b						
Average						

Station	Weight of Sample	Weight of Bag	Weight of Grass	Species A	Species B	Species C
1-a						
1-b						
Average						
2-a						
2-b						
Average						

Station	Weight of Sample	Weight of Bag	Weight of Grass	Species A	Species B	Species C
1-a						
1-b						
Average						
2-a						
2-b						
Average						

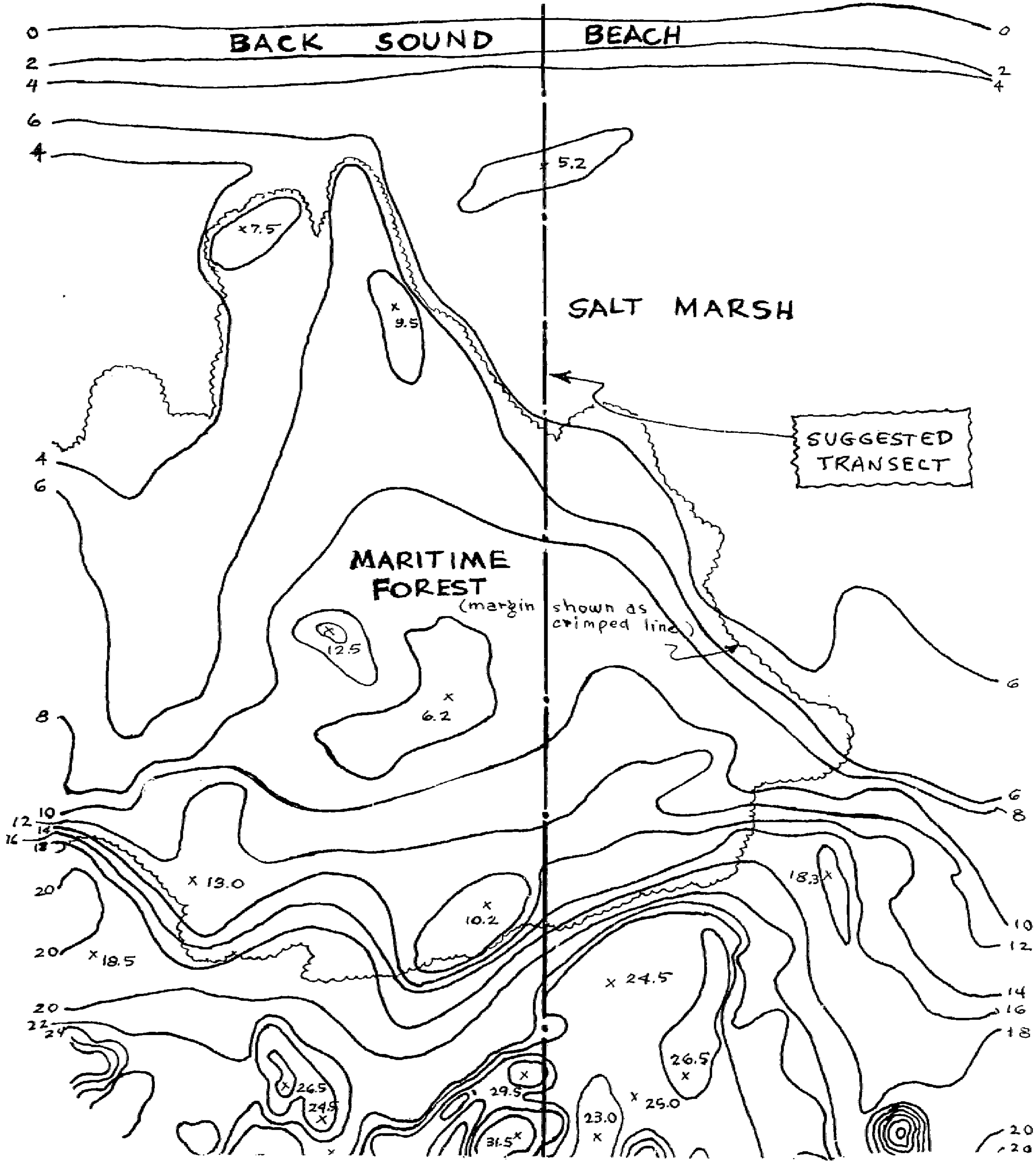
Station	Weight of Sample	Weight of Bag	Weight of Grass	Species A	Species B	Species C
1-a						
1-b						
Average						
2-a						
2-b						
Average						

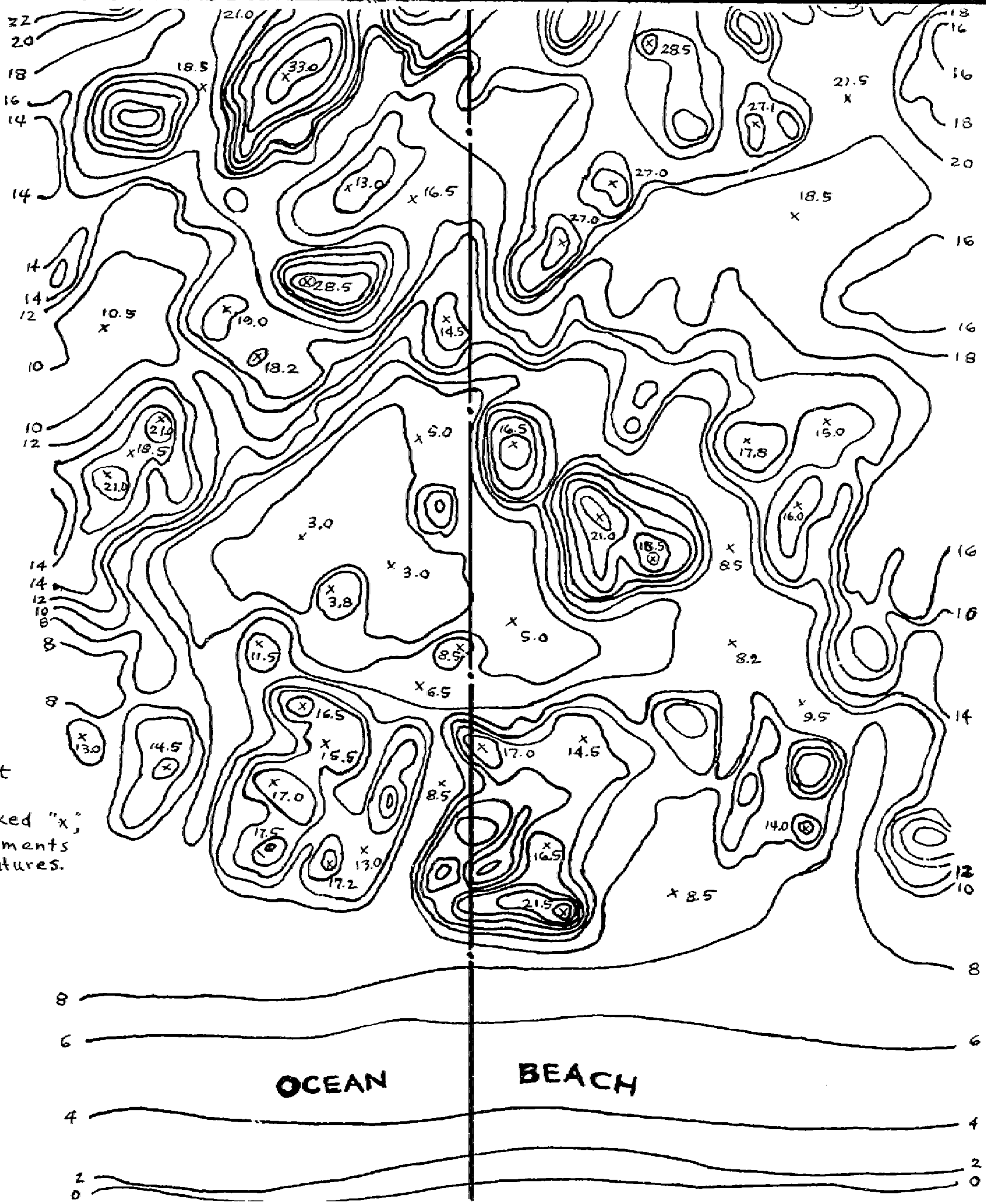
Station	Weight of Sample	Weight of Bag	Weight of Grass	Species A	Species B	Species C
1-a						
1-b						
Average						
2-a						
2-b						
Average						

Consider the Following:

Why is there a change in the amount of plant material across the island? How does this relate to washover? Do the same species dominate dunes and washover sites? If not, why? How will the vegetation change through time, and what will make it change? Could past vegetation exist today? How are the plants you collected adapted to washover? What happens to them when washover occurs? What is the significance of the grasslands to the washover process? What could happen if the grass were destroyed?

Get together with the other washover study group and discuss the sample diagrams of Washover and succession on a barrier island. Explain the features of each stage. How do your data and observations compare with this model?


BACK SOUND
BEACH
SALT MARSH
SUGGESTED TRANSECT
MARITIME FOREST
(margin shown as crimped line)
x 7.5
x 9.5
x 5.2
x 12.5
x 6.2
x 13.0
x 10.2
x 18.5
18.3 x
x 24.5
26.5 x
x 25.0
23.0 x
29.5
31.5 x
26.5
24.5



Contour lines are at 2-foot intervals —
Some points, marked "x", are actual measurements of identifiable features.

FIELD EXERCISE No. 4

Maritime Forest Profile

Objective:

To prepare an elevation profile transect of a barrier island showing the elevation of the living forest compared to the "ghost forest", and to hypothesize on the cause of forest destruction.

Background:

There is unquestionable evidence that sand moved from the beach across earlier woodlands at the turn of the 20th century. However, the cause of this sand movement is unknown. Some event, or events, happened then which broke the vegetative cover on the sand so that the wind could begin moving the dunes into the forest. Some people say that it was caused by man and his domestic animals. Is this the real answer? There is some evidence that such burial may be part of the natural system of outer banks and that to have stopped it would have required excessive manipulation of the land. From an airplane, it is evident that the remaining forest on Shackleford is growing in curving lines, and these lines repeat themselves from east to west along the island. Salt spray plays an important role in selecting and modifying vegetation. Forests can only develop where some protection from salt spray develops such as a dune line, or roof-like leading edge of the forest sloping away from the beach. Where trees are fully exposed to spray, they soon die. In addition, buried forests also die. You will be concerned with such questions as: Why did the sand start moving? What was the elevation of the ghost forest? Can trees grow there now? What will happen in the future?

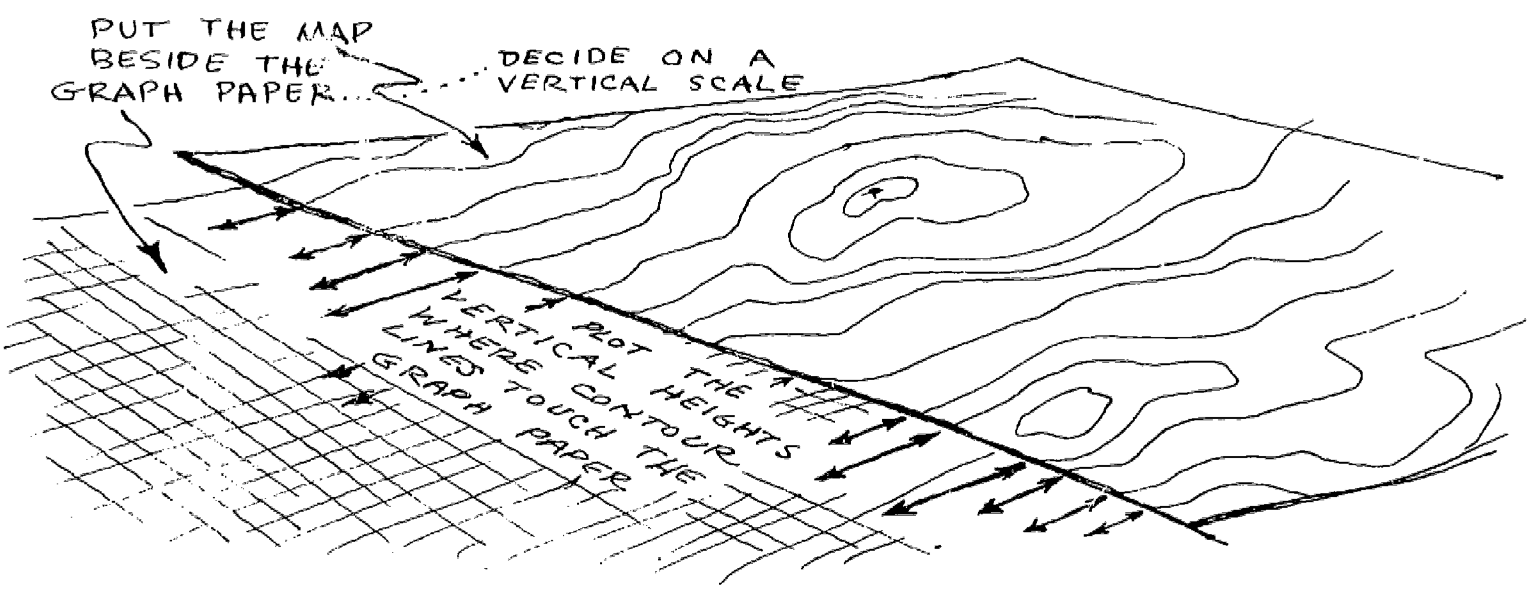
Field Equipment:

Topographic map, compass, measuring pole, graph paper, small shovel.

Field Assignment:

Your work is to be divided into two parts: map study and field reconnaisance. A profile across the island will be made using elevation data taken from the topographic map that will be supplied.

The topographic map consists of lines that indicate elevations of the land at 2-foot intervals. A piece of graph paper is to be marked off with elevation on the vertical axis and distance on the horizontal—use the same scale as on the topographic map. The idea here is to plot selected elevations taken from



(This will be demonstrated for you if not clear) the map (a horizontal description) on a graph to create a vertical profile. The profile base line you are to follow is shown on the map and also on the aerial photograph. Determine the elevation of each contour that the profile crosses and plot this value with its appropriate distance from the base line starting point on the graph.

For example:

With the map orientation lines—which run N-S and E-W—and a compass, you can determine in the field which direction your profile takes. Walk across the island, as close to the map line as you can, through the forest and up into the dunes. While in the forest, determine the height of the trees with a measuring pole, or estimate. You can estimate fairly accurately by having a friend, whose height you know, stand next to a tree while you stand some distance way. Then figure how many times the trees are taller than your friend. Draw the forest profile on your diagram.

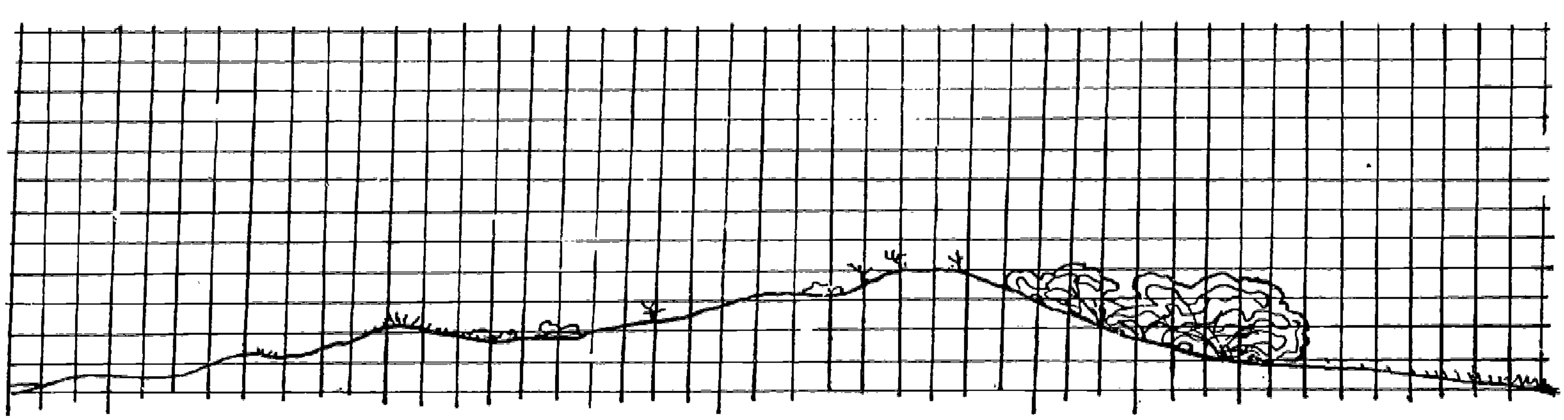
Continue out into the dune zone, and estimate the height of the dead trees and locate these on your profile. By standing on a high dune, you can look around and figure the heights of other dunes, and the elevation of the "ghost tree" areas, with the topographic map. This will be demonstrated for you if necessary. Compare the heights of the dead trees with the living forest.

Next, compare the soil the trees are growing on with the sand in the dunes, and that in the marshes, and inter-dune areas on the beach. Determine where this sand came from. Can you suggest why the trees are growing in curving lines? What do you notice about the structure of the land these trees are on? What do you know about inlets; are inlets something of concern here?

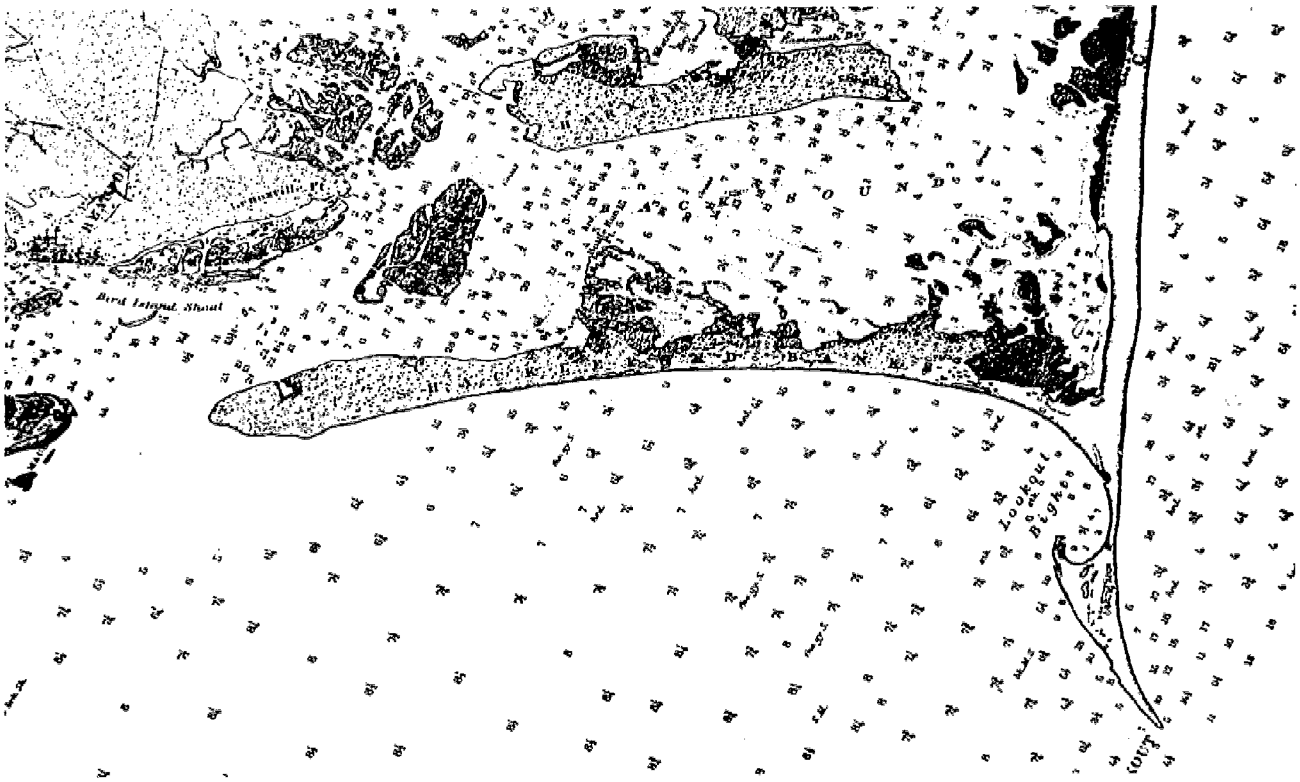
When you have located the ghost forest on your diagram, continue to the beach and locate the seaward limit of stumps. How far beyond is the sea? You can use the topographic map to help you determine distance. Can trees exist there today? Look along the sides of dunes for dark layers of organic matter with white sand underneath. Have you seen such layers before? What do they signify?

Results:

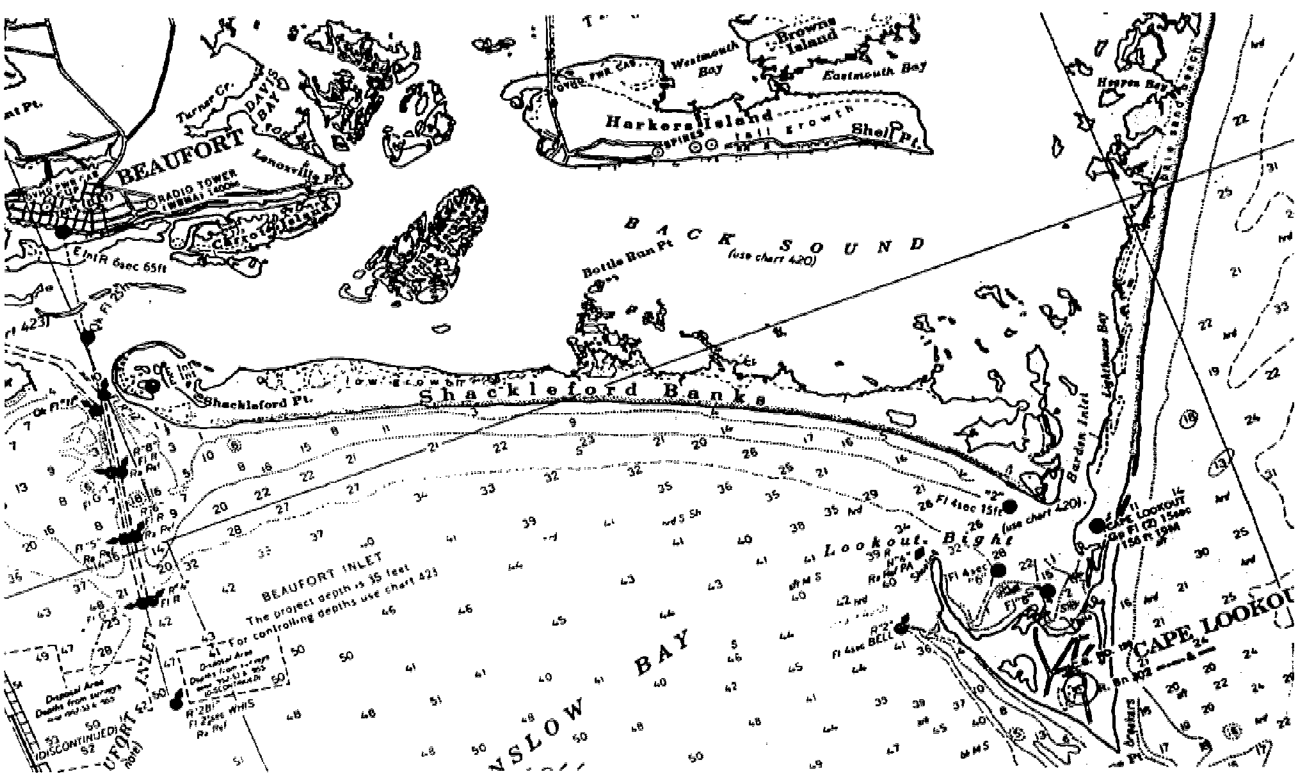
With this data, and comparing the present situation to that in 1850 (refer to the map copies), can you suggest what conditions had to be present when the dead trees were alive? Look closely at the 1850 map because it has a lot of information squeezed into a small area. Where was the surf zone then? What caused the dunes to start moving? Don't forget to consider the ever-present forces of beach erosion, and especially hurricanes. Talk to the students investigating washover and see if you can see any similarities with your area. Can you make any assessment of what effect the herds of grazing animals have on the vegetation and how this might be related to sand movement? What do you think will happen to this area in the future if natural forces continue to act without man's interference? What do you know about succession and can you make any statements about possible changes of vegetation?



Your final diagram should look something like this, only with more detail.



1850 Survey



1966 Survey

FIELD EXERCISE No. 5

Salt Marsh Survey—Mapping

Objective:

To prepare an ecological base map of a salt marsh for further studies, such as elevation surveys, species distribution, and so forth.

Background:

Mapping land surfaces and vegetation is a very important part of ecological studies or any other treatment of land. Maps, as you well know, are indispensible for understanding the relationship of land surfaces to each other, for locating desired places, for accurate travelling, and so forth. Any ecological study in the field will, at some point, require a map. Mapping can also be fun! You will be using a quick, but fairly accurate, method of mapping called "triangulation". Before aerial photography, this method, with considerably more attention paid to detail and accuracy than we can have, was the standard mapping technique. It is still very useful for localized, large scale map needs where aerial photographs are not available. The salt marsh presents an array of vegetation types which are easy to locate and distinguish, and to which environmental factors, such as elevation, can be easily related. A map can also be used to sort out and make sense of other environmental factors—for example, tides, drainage, substrate — and their effects on vegetation.

Equipment:

Table, carpenter's level, triangular ruler, masking tape, pencils, eraser, tape measure, survey pins, stakes or poles, large drawing paper. If a metric triangular ruler is not available, fasten a strip of wood along one edge of a meter stick so that it will stand on its side.

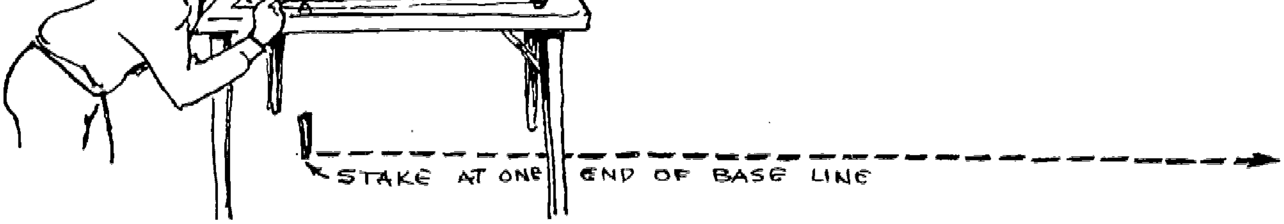
Field Assignment:

You will be mapping the same salt marsh that the elevation survey group is studying. You should get together with them and combine your data.

Decide on the area to be studied, and set out a base line. For example, you can use the telephone poles. This base line should be fairly long . . . at least 30 meters and preferably 70 meters. This line must be measured and marked. Center the table over one end of the measured base line.

Mapping can then be started. Over one end of the base line, set up the table with a large piece of paper taped to it. With the ruler, draw a line near the base of the paper TO SCALE. For example: "1 centimeter = 1 meter". Be sure to record this scale.

The map is made by selecting certain objects or distinguishable points on community boundary lines (for example — shrubs, indentations in the needle rush marsh, the edge of the cordgrass marsh, old tree stumps, edges of the creek, and so forth) and laying the end of the ruler on point A of the base line (remember which side of the ruler you use),

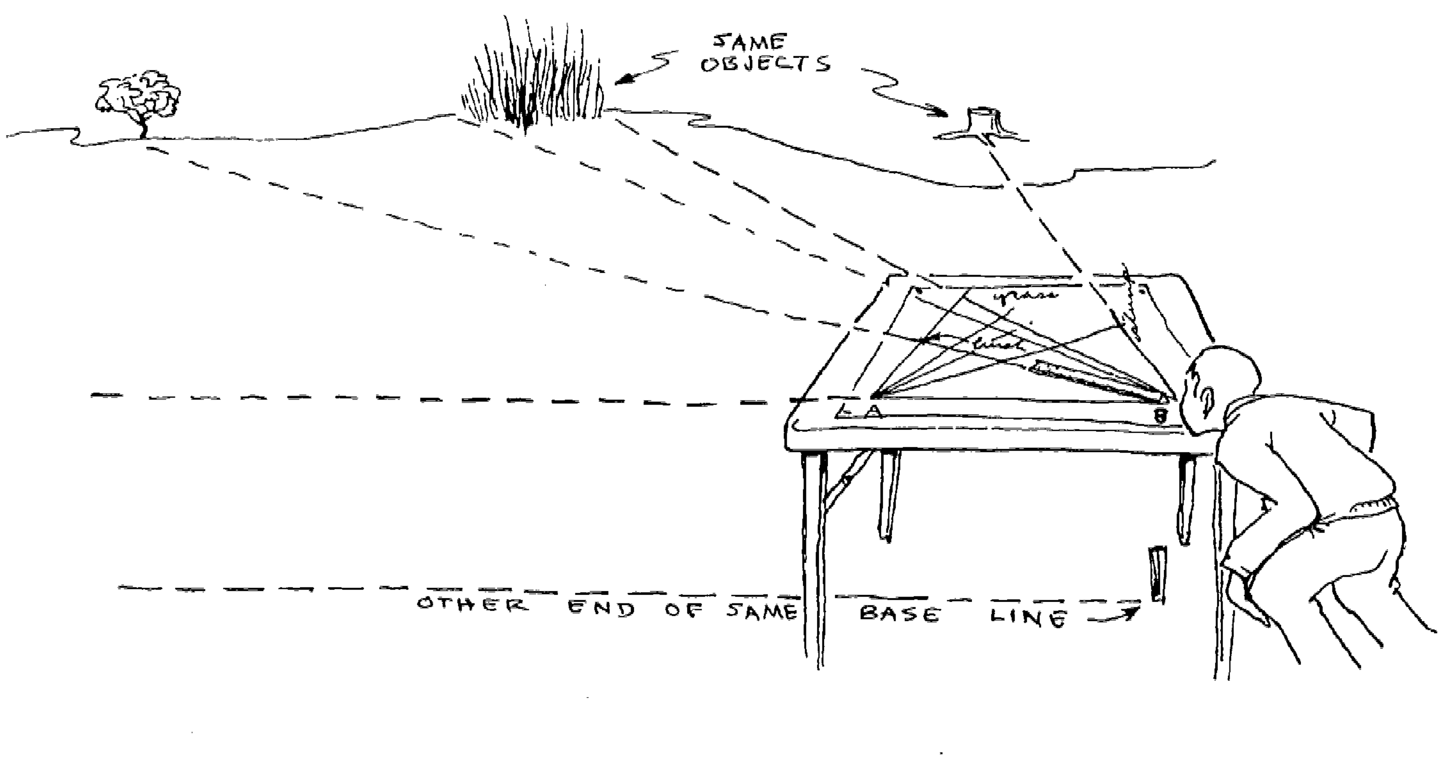


then lining up the ruler with the natural object or a marker you put out. Once you are satisfied that the ruler is aimed properly, draw a line on the paper that connects with the end of the base line. Label the line so you won't forget what you sighted on. (A stake or pole can be put at the point to help you find it later). Repeat this operation several times at different points. Be sure to sight on major vegetation changes or other features from place to place.

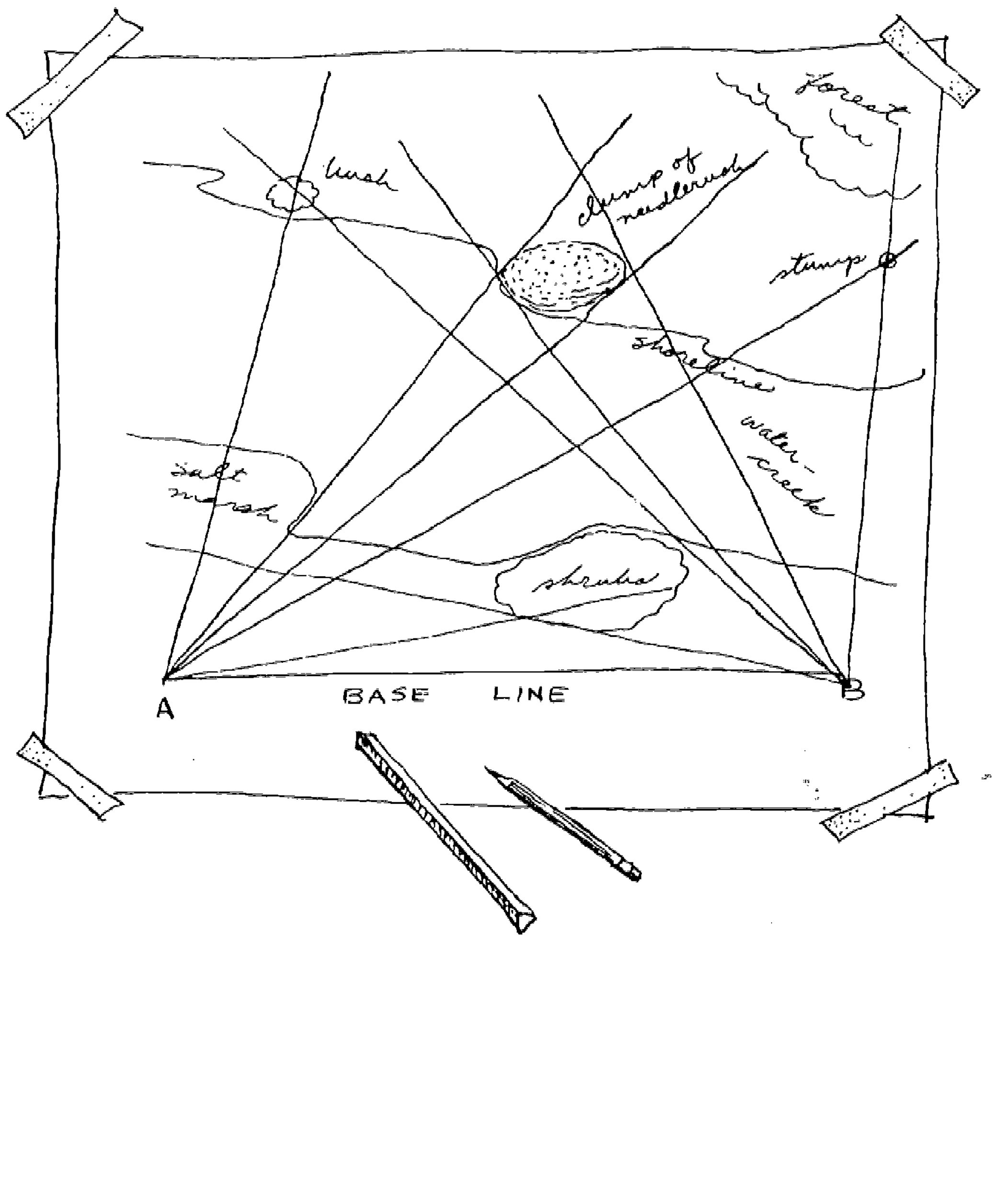
After sighting on as many points as is convenient to at least start the map, move the table to the other end of the measuring base line, and align it as before. Repeat the sightings from point B—ON THE SAME FEATURE AS BEFORE—and draw the lines. Where the lines intersect is where your point is on the map, drawn automatically to scale. Indicate this intersection as a dot, and label it.

When you have a series of points, the map can be completed by "eyeballing" the rest of the area in relation to the mapped features and points. This is done by essentially "connecting the dots" which indicate the locations of the natural features. Show the shapes by drawing the feature as best you can with the points as guides. The greater the number of sightings, the more accurate and detailed your map will become. Sightings can be repeated or added by going back to either end of the transect, and aligning the table carefully in the same positions. More information can thus be added and your map will improve. Once points are located, erase the guide lines so they won't confuse other sightings. Remember, the map is not complete until the natural features are drawn in. (For class purposes, do not erase the sighting lines, so that you can explain how you made the map.)

Be sure to locate the position of the elevation survey transect on your map base line.



Example:
The diagram below shows how your map might look after several sightings.



Consider the Following:
What patterns of vegetation can you see on your map and how do they relate to physiographic features: creeks, sand bars, and so forth? Can you relate vegetation patterns to elevation, or drainage, or salt or fresh water? Discuss the role of mapping in ecological studies.

FIELD EXERCISE No. 6

Salt Marsh Survey—Elevations

Objective:

To determine elevation changes, if any, between vegetation types in a salt marsh area, and locate the elevations on a map.

Background:

The relationship between sea level and the elevation of land is very critical along coastal areas in determining plant zonation. Changes of a few inches can have a profound effect on the vegetation one sees where the land and sea meet. The structure of salt marshes is closely tied to the land elevation, and the zonation that occurs in a marsh may be due to slight changes in this elevation. However, other factors may also affect the zonation. As with many other situations on the the outer banks, change is a very common feature in marsh areas, and major changes in plant communities can be related to sea level variations. You will be concerned with such questions as: Is there an elevational difference between cordgrass marsh and needle rush marsh? What is the elevational range in which salt marsh cordgrass grows best? How does the salt marsh elevation compare with the elevation of other plant communities?

Field Equipment:

Surveyor's level, sighting rod, notebook, rubber boots, graph paper.

Field Assignment:

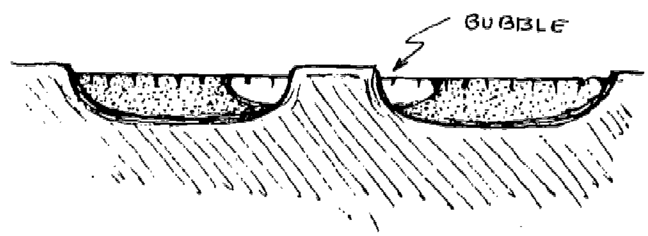
You will work closely with the group that is mapping the salt marsh area, and your data will be located on their map.

The surveyor's level, which will be set up and demonstrated by the trip leader, is the primary tool for the survey. The graduated rod is used as the sighting target and will provide the elevation readings. Its use will also be demonstrated by the trip leader.

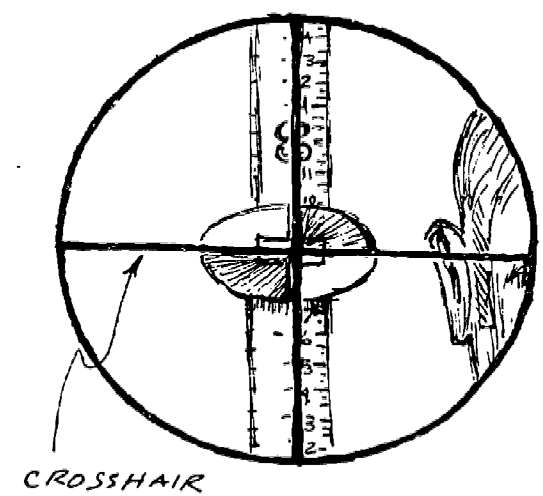
Once the level is set up, a transect series will be run across the marsh, and elevations determined for major vegetation changes such as: edge of salt marsh cord grass zone, edge of grass along a creek, depth of creek bottom, elevation of old stumps, needlerush zone, shrub zone.

Surveying:

Care must be taken to make sure the sighting level is always leveled before reading. This will be demonstrated. Check the bubble carefully and make sure that the gradations on the one side equal those on the other.



The instrument is focused by means of a knob on top of the barrel. Sighting is done as with a rifle telescopic sight, and the moveable red and white target of the sighting rod is aligned with the cross hairs. The target is moved up or down by the rod man depending on the instructions of the surveyor. The surveyor will indicate when it is at the right elevation. The elevation is read off the rod and recorded by a recorder.



The set up and type of measurements needed are as follows:

a=height of the level over the ground on a dune line.

b,c,d,e,f,g, . . .=height of target over the ground at different locations.

X=height of level over a selected base line such as the high tide mark, or preferably on a bench mark if one is nearby. The sighting is made after completing the survey by turning the level around.

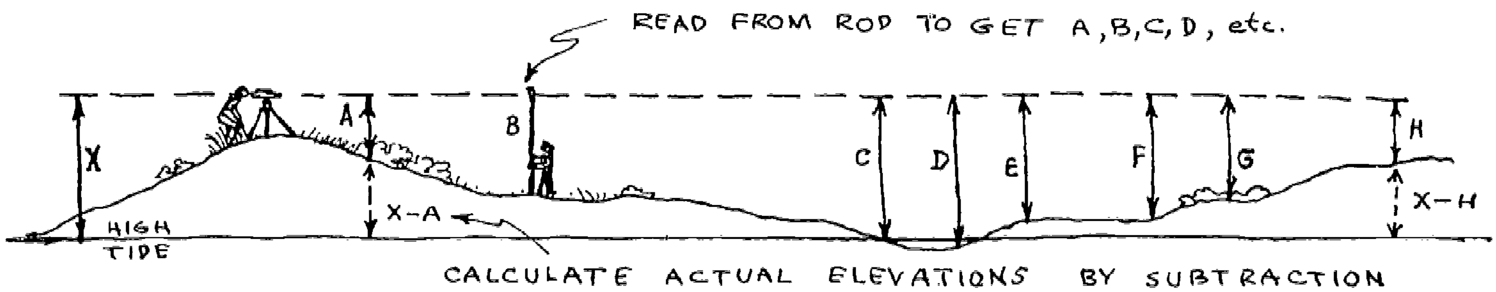
Then: X — a, X — b, X — c, etc. = elevation above or below the base line (in this case, relative high tide mark)

When U.S.G.S. bench marks are nearby, such surveys can be corrected to sea level, which for accurate surveys is essential. Sea level is somewhat difficult to determine in the field and thus known marks have to be used. Relative base lines such as low tide, high tide, approximate mean tide line can be used and for our purposes are sufficient.

Data:

List your data, kept by a recorder who accompanies the rod man, in the table provided.

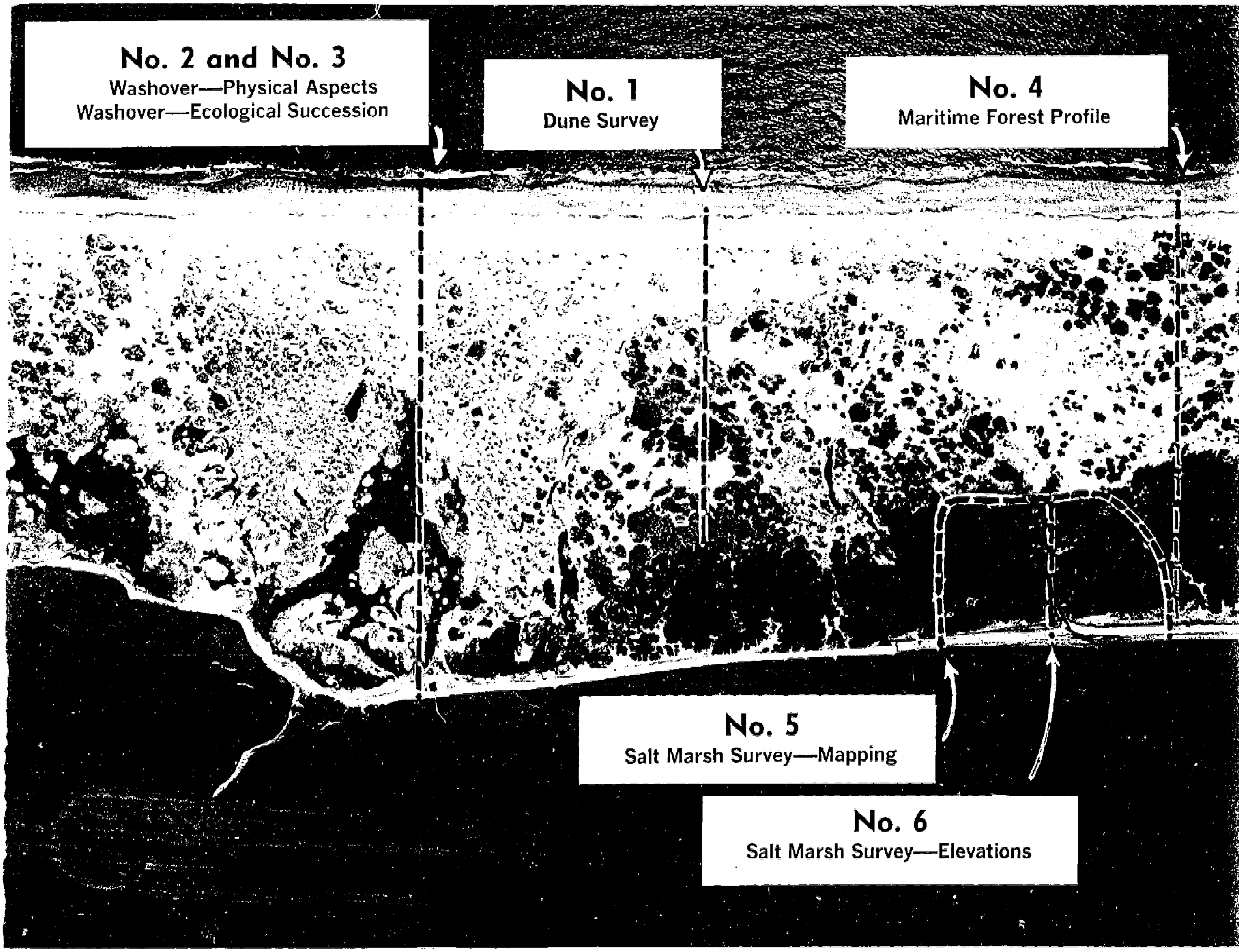
Plot this data as a profile diagram shown in the example below and draw to scale. Locate the transect on the map being made of your area. Other sightings of interest can be made away from the transect if time permits, and located on the map. Remember — ALWAYS KEEP THE INSTRUMENT LEVEL!



Consider the Following:

What is the magnitude of elevation changes between plant communities? Is elevation the most important ecological factor? What is the elevation of the salt **meadow** cordgrass community and how does it relate to the salt marsh, to creeks, and surrounding areas? At what elevation do the salt marsh shrubs grow? How about the maritime forest? What does the presence of stumps, and their elevation, tell you about sea level? Can trees grow there now? What is the vegetation that grows at lowest, intermediate, and high elevations? What can you say about the presence of water in the area, and can you classify vegetation in relation to the tidal changes that you think occur?

Position	Location	Rod reading	X	Relative elevation	Paces between positions



Typical Study Area

The area of Shackleford Banks used by the Marine Science Project is shown here. It is about the middle of the island at the site of a severe washover and probably a former inlet.

The cabins are privately owned. Their use by the Project has been by prior arrangement and by courtesy of the owners. Other groups coming to the area should not rely on their availability, but the Marine Science Project will make inquiries for you if requested to do so.

Since the cabins are occupied much of the summer and fall, camping out may be a more realistic plan. There is ample space and no landowner objection. There is no reliable source of water, so everything you need should be taken with you. There is ample firewood, however, in the drift areas on the sound side.

Shackleford Banks is to be the last link in Cape Lookout National Seashore. The State of North Carolina must first acquire the several islands north of Cape Lookout and turn them over to the National Park Service, which will then purchase Shackleford. This may happen about 1975.

In early plans, Shackleford Banks was scheduled for development as an intensive camping area. However, the latest plans call for minimal changes in its natural state and access only by boat. The area pictured here as the site for these field exercises may well be designated as one of the official National Environmental Study Areas. Whatever the Cape Lookout National Seashore schedule and plans, the area will be available for quite a while as an ideal place to study the variety of coastal processes discussed in these exercises.

Other Field Exercises

The preceding research problems were designed for a specific island, Shackleford Banks, which is a southfacing barrier beach near Cape Lookout, North Carolina. Some of these exercises can undoubtedly be used on other beach situations. However, you must come up with field work that is relevant and feasible in the area to be studied. Take these exercises and adapt them, borrow portions from them and combine parts, invent similar new ones or, if ample time is available, let the students create their own problems.

A few of the other subjects which could be successfully explored in this area are:

1. Effects of feral animals. Several species of domestic animals have been released on Shackleford Banks (and most other barrier islands). They selectively graze the vegetation, create paths, compact the soil in some places and chop it up in others, leave droppings and are hosts for parasites, among their many roles on the islands. Current philosophy is that they may be responsible for greatly holding back plant succession and stabilization of the dunes. Since sheep, goats, pigs, ponies and cows are quite different in their impact on an environment, an interesting but difficult study could be based on identification of tracks, droppings and signs of feeding.

2. Aquatic populations. There are many interesting habitats created on the sound side of a barrier island. Any tidal creek makes a good subject. For example, do animals move up into a tidal creek with each flooding tide, and retreat with the ebbing flow? To find out, take a minnow seine and sample one spot in the creek every three hours through one complete tidal cycle (twelve hours). Compare species composition and analyze feeding types making up each sample. Some pools are partially isolated. Because of dikes across their mouths, they are filled only by the highest tides and never completely drain. Recall that there is a semi-monthly cycle of spring and neap tides.

3. Response of intertidal plants to conditions of their zone. Although saltmarsh cordgrass seems to be **the** intertidal plant in this area, the story is much more complex. Why does the cordgrass grow much taller at the lower edge of the marsh and become progressively shorter toward the upper margin? Why are there bare spots in the higher portions, often with glasswort taking over? Why is there a margin of bare mudflat out beyond the cordgrass at extreme low tide? Why does black needlerush appear in some areas that seem to be cordgrass domain?

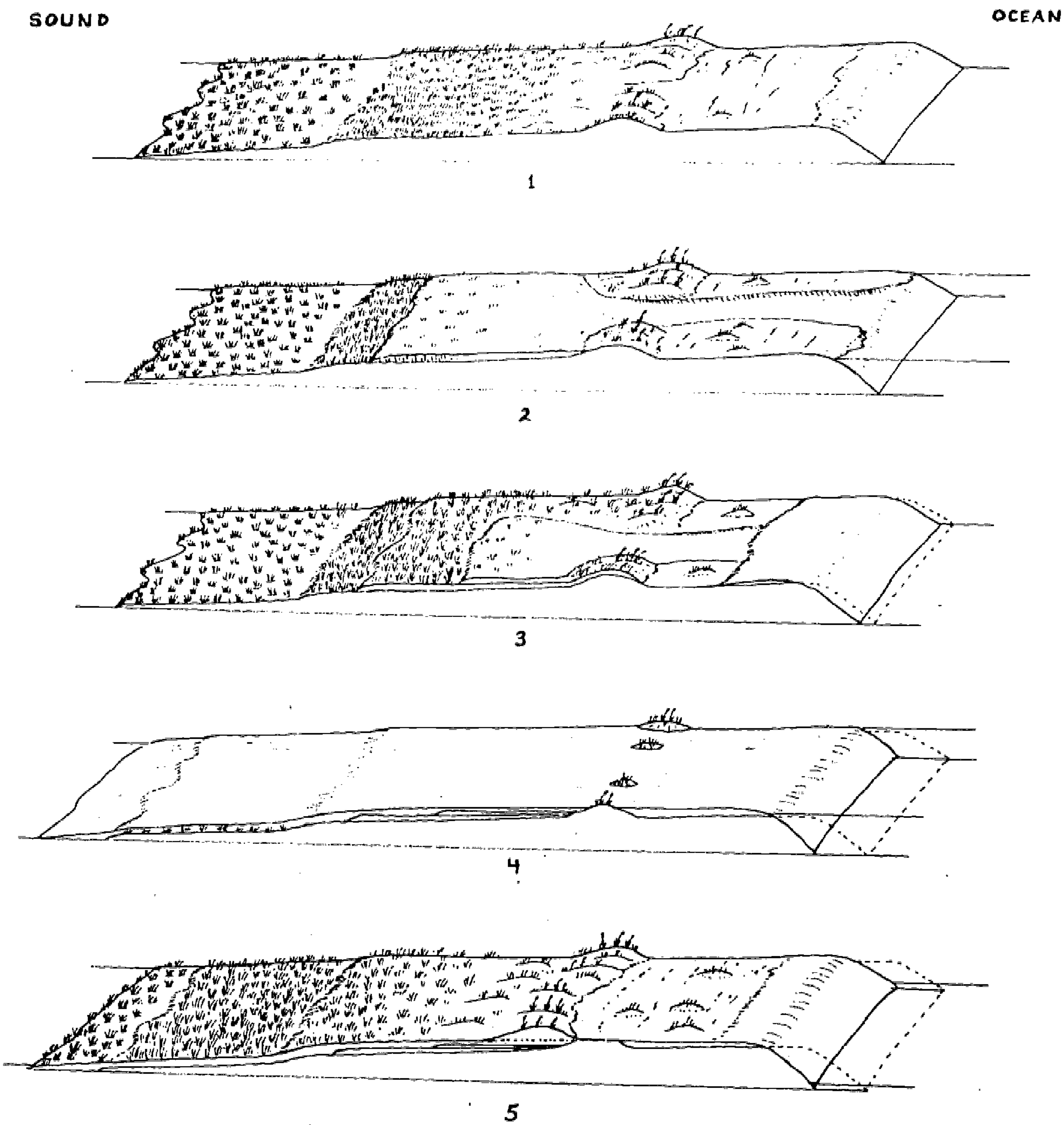
4. Water tables and water quality. That ponies can get potable water by digging holes with their hooves near the sound, (cows, incidentally, can not, and sometimes follow the ponies to drink from their "wells") indicates the complex relationship between saltwater and fresh water. A series of test wells and simple chemical tests of salinity, hardness and depth of water table would be enlightening.

5. Terrestrial animals. While animal life is minimal on Shackleford, a small mammal trap line or a Berlese funnel count of soil fauna might be tried.

The ocean beach has potential not even hinted at in these exercises, the assumption being that there are easier ways to get at an ocean beach, and that a Shackleford trip should capitalize on the chance to study dunes undisturbed by human settlement. If these studies are done in another locale, however, beach studies could well be a part of the picture. In fact, the most valuable use of these exercises would be to pick out a permanent area easily accessible to school and turn it into a long-term living laboratory. Select a transect perhaps a few hundred meters wide, and, over the years, use a series of classes to build up a comprehensive picture of the physical processes that have created it and the successional development underway. The study would have intrinsic value and would be of interest to professional ecologists.

However, the exercises herein, as used by the Marine Science Project, are more for the purpose of teaching students how to do field research than for the collection of data. Dr. Godfrey, fortunately, had the opportunity to study Shackleford Banks ecology for two years, and it is relatively well documented.

Above all, let the students do the work. Then let them report on it in their own way. There is plenty of room for an instructor's guidance, but professorial lecturing by the teacher will take away most of the unique benefits these trips have to offer. What's more, the students will really do a great job and gain a great deal of self confidence and research insight!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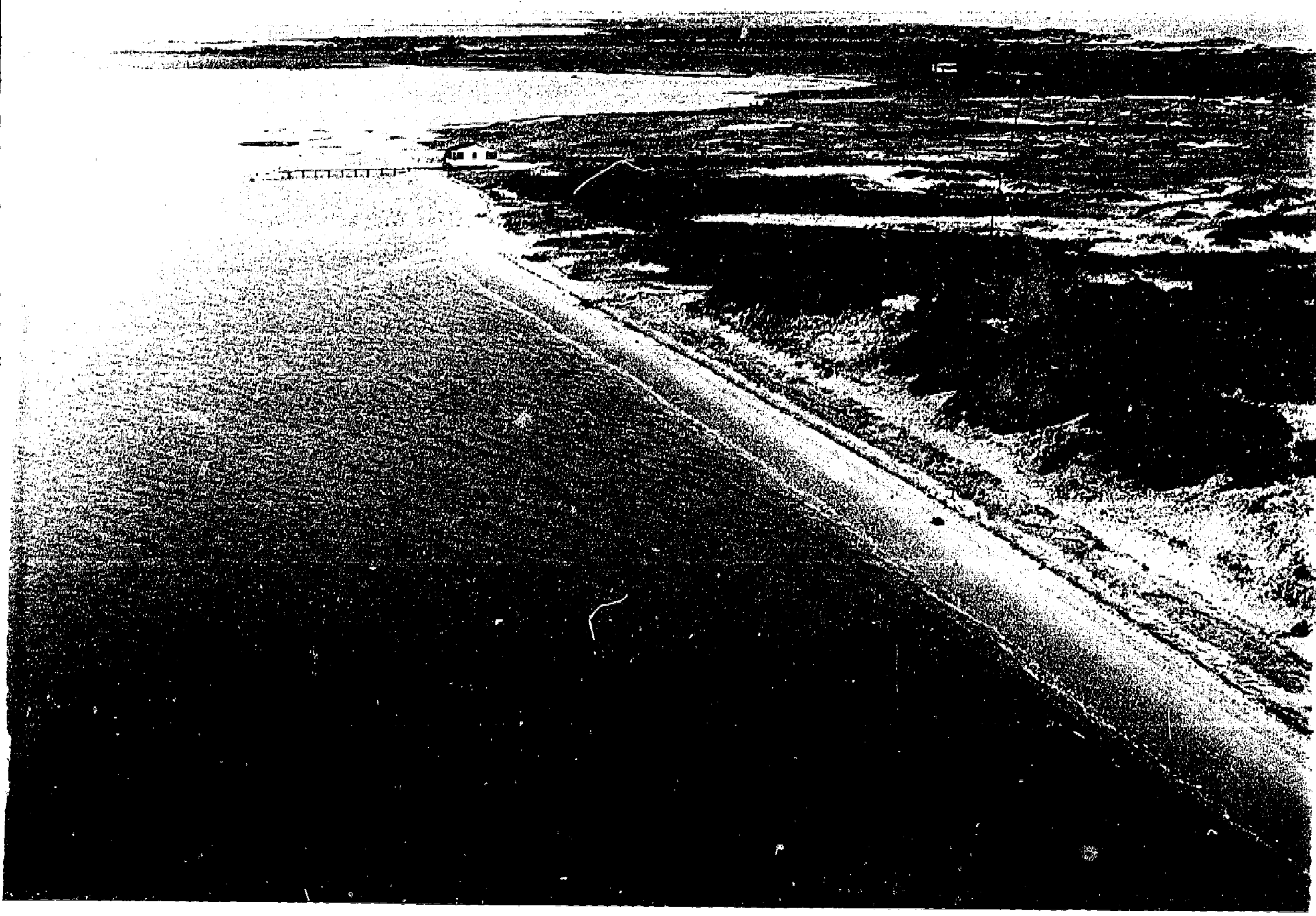

Acknowledgements

This publication is a product of the exceptional cooperation given to educators by professional biologists. Cape Lookout National Seashore made available the services and talents of Dr. Godfrey to lead the trips on which he based these exercises. They also provided photographs on pages 4, 9, 10, and 31 (by Bob Simpson), page 18 (by Paul Godfrey), and page 28 (by American Air Surveys, Inc.).

The Marine Science Project conducted the trips as part of its advanced courses in marine ecology, with Will Hon adding the educational footnotes to Godfrey's exercises. Art work is by Will Hon except for the U. S. Coast and Geodetic Survey maps on page 21 and Dr. Godfrey's summary of the washover phenomenon on page 30. Photographs on the inside covers and page 2 are by the staff of the Marine Science Project.

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by the

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of the

CARTERET COUNTY PUBLIC SCHOOLS

Beaufort, N. C.

T. Lenwood Lee, Superintendent

This publication is designed for use as part of a curriculum series developed by the Regional Marine Science Project of the Carteret County Public Schools, financed primarily by ESEA TITLE III. The series will include three-week teaching units for grades four through ten and two full-year courses in advanced biology. The tenth grade unit will consist of a three-week fall and a three-week spring unit.

All materials take an ecological approach to nature, stressing the ties between culture, economy and resource use. Field work is an integral part of the curriculum.

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